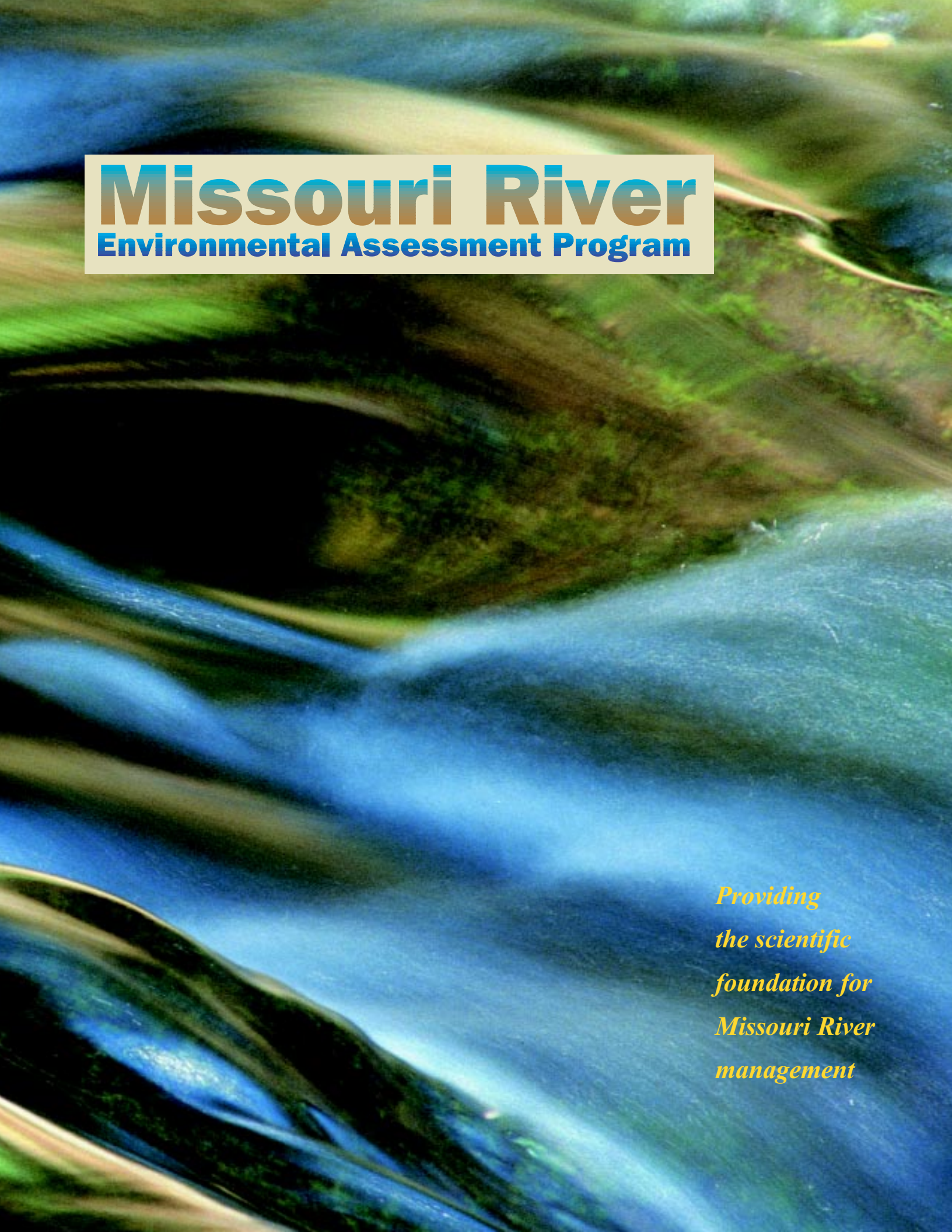


Missouri River
Environmental Assessment Program

Providing the scientific foundation for Missouri River management

Goal of the Missouri River Environmental Assessment Program

To provide the scientific basis for balanced management of the Missouri River's main stem and floodplain fish and wildlife resources while avoiding or minimizing conflicts with other river uses

Missouri River
Environmental Assessment Program

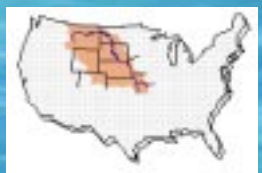
Niobrara State Park
Niobrara River and Missouri
River Confluence, Nebraska

a publication of the
Missouri River Natural Resources Committee
in partnership with the
U.S. Geological Survey, Biological Resources Division

EXECUTIVE SUMMARY

Why the program came about. What it will accomplish. Its costs and benefits.

Yellowstone River flowing into the Missouri River near Williston, North Dakota



Missouri River Basin

The Missouri River system is managed for:

- flood control
- navigation
- irrigation
- hydroelectric power generation
- municipal & industrial water supplies
- water quality
- recreation
- fish & wildlife, including endangered species

The Missouri River

is 2,341 miles long and drains one-sixth of the United States. In the past 60 years, one-third of the river has been channelized and another third impounded.[29] These changes have provided important benefits for Missouri River Basin citizens but also significantly altered the ecosystem.

Today, four riverine species are federally-listed as endangered or threatened, two are candidates for federal listing, and eight are species of special concern to state or federal fish and wildlife management agencies. Other species of recreational or commercial importance have also declined substantially in some river reaches.

The decline of native species, combined with drought and flood events over the past decade, has led to a basin-wide debate about river system management. Understanding how management decisions affect the river environment is essential for the long-term health of the resource and realization of the river's full economic potential.

Why

The 1988-92 Great Plains drought so negatively impacted the upper basin recreational economy and lower river navigation that it prompted a review of the U.S. Army Corps (Corps) *Master Water Control Manual (Master Manual)* which governs reservoir operations. This review focused attention not only on river water allocation issues, but on the fish and wildlife resource problems.

In 1994, the Corps issued the *Master Manual Draft Environmental Impact Statement* (EIS) and conducted public hearings. These hearings clearly demonstrated the many, and sometimes conflicting, human demands made upon the river system, but also demonstrated a general consensus on the need for collecting comprehensive, long-term natural resource data to understand the effects of any future river management decisions.

Scientific understanding is required to make informed management decisions.

This consensus is critical to establishing an effective environmental monitoring and assessment program. Monitoring data are used to define the river's baseline environmental condition so trends can be identified and progress measured. Programs developed to conserve and restore fish and wildlife populations in highly modified river systems must have this information available or risk expending large sums of money without correcting resource problems. For example, over $400 million a year is spent in the Columbia River basin to restore salmon populations, yet the program has failed to reverse the decline [21] and may actually conflict with other management goals and conservation efforts.[52]

After the *Master Manual* public hearings, the Corps asked the **Missouri River Basin Association (MRBA)** to help develop elements of a river operating plan that would be more acceptable to basin states and tribes. Created in 1981 by the Governors of the basin states, the MRBA coordinates planning activities and resolves water management issues. The MRBA confirmed the need for a basin-wide environmental assessment program and requested planning assistance from the **Missouri River Natural Resources Committee (MRNRC),** a group of state fish and wildlife agency representatives whose mission is to implement a systems approach to managing Missouri River natural resources.

What

In August, 1996, the MRNRC initiated a cooperative partnership to develop a comprehensive plan, entitled the **Missouri River Environmental Assessment Program** (Program)**.** The Program's purpose is to provide the scientific foundation for Missouri River management decisions. It seeks to identify successful, cost-effective approaches to conserving and restoring the river's fish and wildlife populations while maintaining current benefits provided to residents of the Missouri River basin.

The Program proposes to both expand upon existing state and federal monitoring programs and initiate new monitoring efforts to assess the biological, physical, and chemical responses to changes in Missouri River system operation and maintenance (O&M). It will establish a system-wide database on Missouri River fish and wildlife, habitat, and water quality, and define the baseline environmental condition of today's river.

To guide management actions and habitat restoration, the Program will conduct:

- ***long-term monitoring*** to define the baseline condition of river resources, and over time, identify trends
- ***focused investigations*** to predict cause-and-effect relationships between system O&M and the response of the biotic community

What is learned by integrating focused investigations with long-term monitoring will be applied to river management and restoration activities by resource agencies and the Corps. This information is critical to managing and restoring the river system as a whole so that at-risk species can be recovered, while recreationally important fish and wildlife resources are maintained and enhanced.

Cost

To conduct system-wide monitoring and focused investigations, the Program proposes 5 state-run field stations and a central support facility at an annual cost of $12.5 million. Direct federal costs of $10.7 million will be combined with in-kind contributions by the states of $1.8 million. One-time start up costs will be $3.3 million. The Program will operate for 15 years with the option to extend the entire program or individual components.

Program Benefits

Systemic sampling of the Missouri River will provide data and information that benefits all river interests.

Operation & Maintenance

System operation and maintenance (O&M) currently entails:

- regulating releases from upper river reservoirs
- maintaining bank stabilization and navigation training structures
- maintaining and repairing flood control levees
- operating and maintaining flood-plain drainage systems

All of these activities affect river fish and wildlife to varying degrees and must comply with various permitting and environmental regulations. The data collected through the Program will assist in evaluating and mitigating the impacts of O&M, in allocating resources among activities, and in providing greater certainty to the Corps and other stakeholders regarding future planning.

Agriculture & Flood Control

Floodplain agriculture and local and state agencies with floodplain management responsibilities will benefit from accurate data on river stage relationships to surface flooding, interior drainage problems, and high water tables. The data collected by the Program will be useful in the evaluation of flood hazard mitigation and avoidance options, the location and height of levees, the identification of high-risk zones within the Missouri River floodplain, and the importance of floodplain storage in reducing flood stages.

Navigation & Hydropower

By better understanding the reach-by-reach condition of river fish and wildlife resources, reservoir management actions and habitat restoration projects can be targeted to avoid or minimize conflicts with navigation and hydro-power generation.

The Program will result in better designed restoration projects and management decisions which benefit the river ecosystem as a whole. This in turn will reduce the need for future management actions devoted to listing and recovery of additional federally-listed endangered and threatened species which only promises to decrease flexibility and certainty for river managers and users.

Fish & Wildlife

State and federal natural resource and water management agencies need data which will help identify how to meet the habitat needs of federally-listed and other at-risk species in the Missouri River while providing for the needs of other users. Implementing successful restoration strategies and cost-effective recovery of at-risk species will also enhance economically important fish and wildlife resources.

Without innovative restoration projects guided by good science, further declines in existing resources are inevitable, as are additional federal listings of river species as endangered or threatened. This could increase rather than resolve conflict and contribute to protracted litigation.

The Program will identify reservoir releases and water levels which benefit fish and wildlife management goals, while ensuring that objectives for flood control, navigation, power generation, and other purposes are met.

Natural chute formed from recent floods on the 2,200 acre Lisbon Bottoms, part of the Big Muddy National Fish and Wildlife Refuge, south of Glasgow, Missouri

Habitat Restoration

The information collected through *long-term monitoring* and *focused investigations* will be applied to restore and manage aquatic and terrestrial habitats located on public lands along the river. Currently, eighty-four publicly owned areas are located adjacent to the river from below Fort Peck Reservoir in Montana to the mouth at St. Louis.[30]

Additionally, a number of habitat acquisition and restoration initiatives are currently being pursued on the lower river, including:

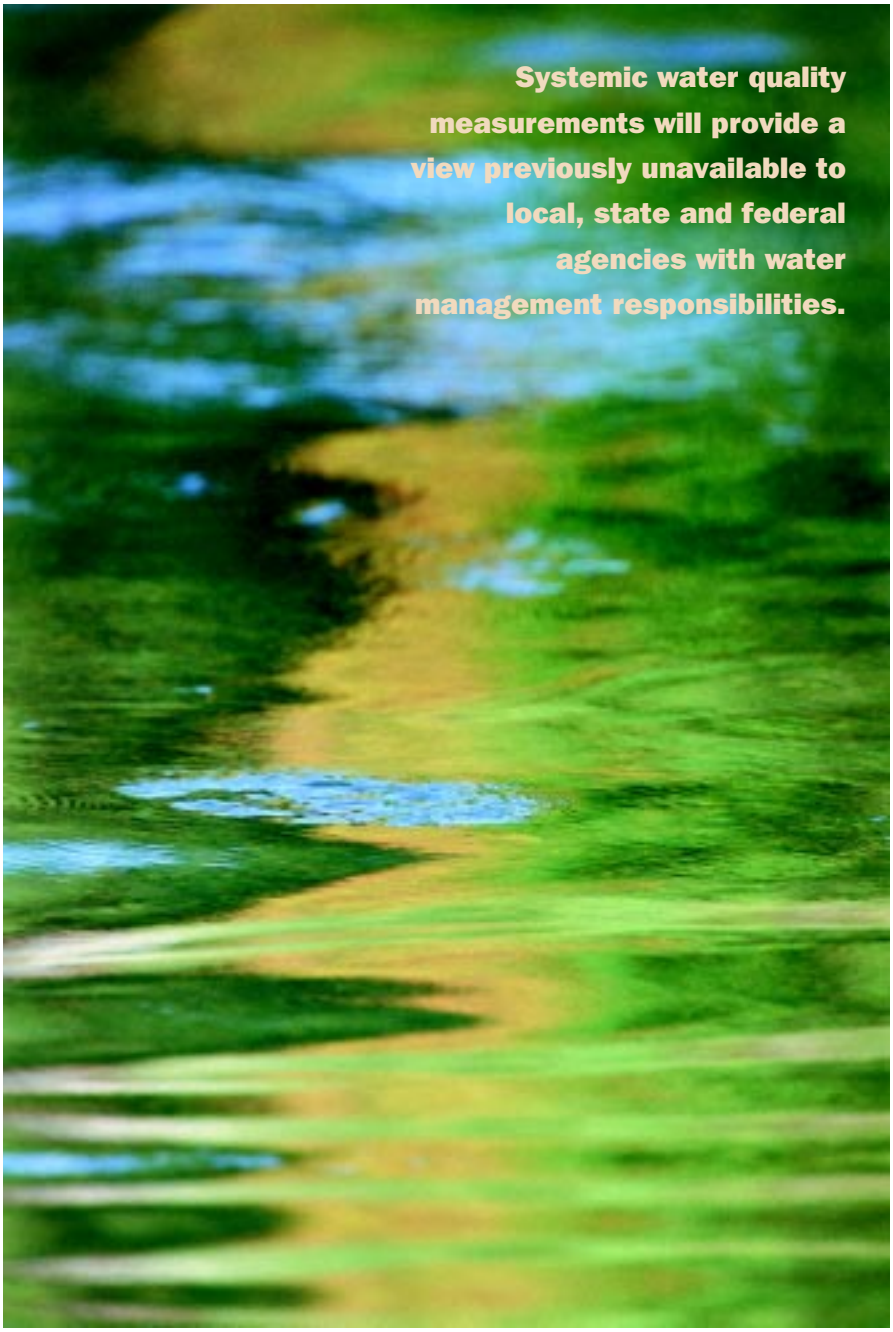
- the Corps' *Missouri River Fish and Wildlife Mitigation Project*
- U.S. Fish and Wildlife Service's *Big Muddy National Fish and Wildlife Refuge* and the *Boyer Chute National Wildlife Refuge*
- Missouri Department of Conservation's *Riverlands Project*
- Section 1135 cost-shared projects of the Corps, states, and local conservation districts

Engineered chute on the 1,637 acre Hamburg Bend Wildlife Management Area, south of Nebraska City, Nebraska

Water Quality

Millions of people depend on water from the Missouri River. Monitoring the quality of the water will help determine the relationship between river flows and water quality. It will aid in showing the effects of river and reservoir water quality on fish and wildlife population levels. Water quality monitoring will also aid understanding of the role of floodplain wetlands in absorbing and processing nitrogen, phosphorus, and contaminants in runoff waters. The data collected will help identify sources of contaminants and nutrients that pollute public water supplies and hinder attainment of state water quality standards.

Testing will complement, not duplicate, existing state and federal monitoring efforts. The USGS stream gaging and water quality network will be greatly expanded with the addition of sites on reservoirs and tributaries. The USGS National Stream Quality Accounting Network (NASQAN) will be augmented for contaminants testing. Building on 30 years of existing data collection networks allows the Program to use resources more efficiently.



Recreation

Recreational activities associated with fishing, hunting, and wildlife watching produce economic benefits for local communities by increasing jobs, property values, and local tax revenue.[8] By identifying specific resource problem areas, the Program will help managers focus management actions on producing healthy fish and wildlife populations, the foundation of these recreational activities.

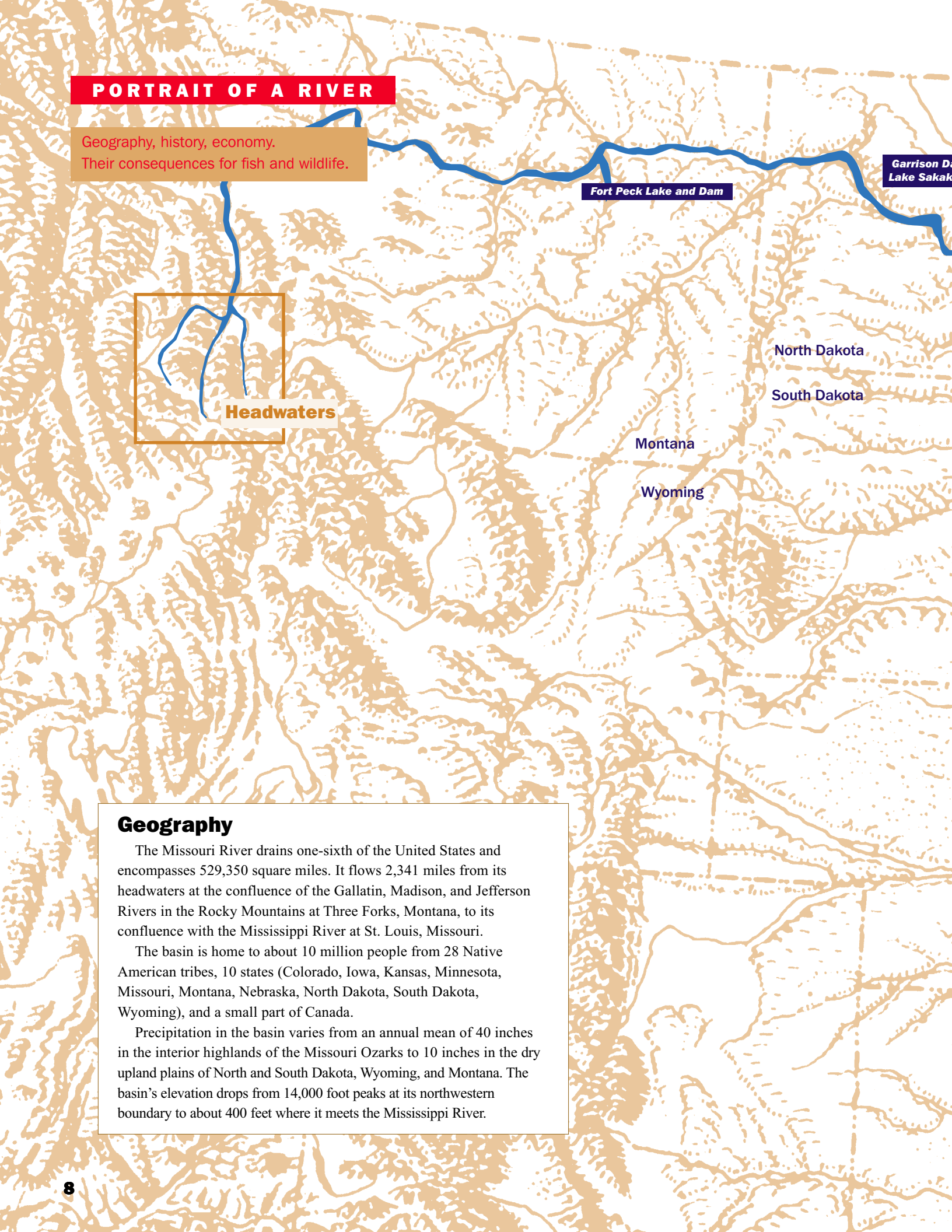
As part of the *Master Manual* review process (see page 2), the Corps estimated the economic benefits associated with the modern Missouri River system to be in excess of $1 billion annually. These substantial benefits accrue primarily to power generation and water supply. Today, an evolving recreational sector is

increasing in importance and represents a potential economic growth area.

According to the *Master Manual* recreation economics study, hunting, fishing, sight-seeing, boating, and camping activities on the river already generate 10 million recreation days and an annual economic benefit of $87.1 million per year for the entire river system.[46]

State estimates are considerably higher. South Dakota estimates that Lake Oahe anglers alone provided $15.5 million to local economies in 1995.[24] In 1997, 600,000 Missouri River angler trips in South Dakota provided $45 million to local economies.[37] A 1990 Missouri recreational use study indicates that over the 4-year period of the study, 2.5 million people visited the Missouri River in the state, spending 12.6 million hours using the resource.[38]

Missouri River recreational benefits are estimated to be in excess of $87 million annually, yet the full economic potential of recreation has yet to be reached.



Geography

The Missouri River drains one-sixth of the United States and encompasses 529,350 square miles. It flows 2,341 miles from its headwaters at the confluence of the Gallatin, Madison, and Jefferson Rivers in the Rocky Mountains at Three Forks, Montana, to its confluence with the Mississippi River at St. Louis, Missouri.

The basin is home to about 10 million people from 28 Native American tribes, 10 states (Colorado, Iowa, Kansas, Minnesota, Missouri, Montana, Nebraska, North Dakota, South Dakota, Wyoming), and a small part of Canada.

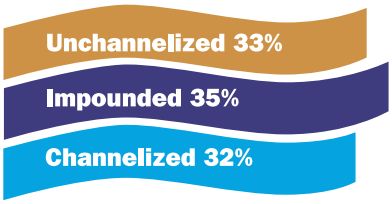
Precipitation in the basin varies from an annual mean of 40 inches in the interior highlands of the Missouri Ozarks to 10 inches in the dry upland plains of North and South Dakota, Wyoming, and Montana. The basin's elevation drops from 14,000 foot peaks at its northwestern boundary to about 400 feet where it meets the Mississippi River.

Like most large rivers in the developed world, the Missouri has been altered by damming, channelization, flow control, and pollution. These changes have significantly impacted native fish and wildlife resources.[6,11,22,25,35,36]

Man-made changes

The pre-development Missouri River represented one of North America's most diverse ecosystems with abundant braided channels, riparian lands, chutes, sloughs, islands, sandbars, and backwater areas. These riverine and floodplain habitats were created and maintained by erosion and deposition which continuously reshaped the channel and floodplain.[32] The Missouri carried high sediment loads, earning it the nickname "Big Muddy."

Two programs, the *Pick/Sloan Plan* (1944) and the *Missouri River Bank Stabilization and Navigation Project* (1945) transformed the free-flowing river into a system of main stem reservoirs in the upper river and highly altered riverine reaches influenced by self-channelization, bank stabilization, and regulated flows in the lower river. Today, 35-percent of the Missouri River is impounded, 32-percent has been channelized, and 33-percent is unchannelized.[39]



In addition to the main stem modifications, the river is influenced by construction of levees along the lower river and major tributaries, channelization of floodplain tributaries, and an extensive reservoir system in the large tributary basins of the Platte, Kansas, and Osage Rivers.

These changes have significantly altered the Missouri River ecosystem. In the upper river, a new ecosystem has been created with the deep water reservoirs replacing the free-flowing river and inter-reservoir reaches affected by lower water temperatures and reduced sediment loads. In the lower river, channelization has eliminated sandbars, depth diversity, and river connections with off-channel side channels and backwaters. The historical flow regime has been transformed with spring high flows now captured in reservoirs and low summer and fall flows augmented with reservoir releases.

All of these changes have lowered populations for many river fish and bird species, some to the extent that they are federal or state-listed as endangered, threatened, or species of special concern.[36]

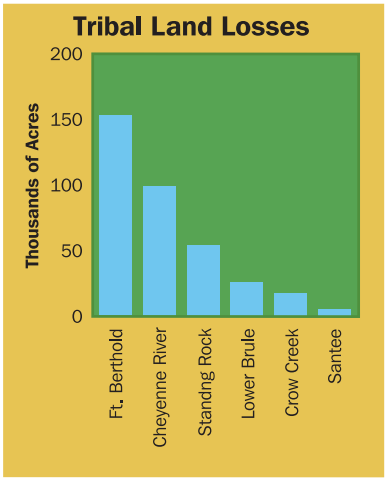
Reservoirs and Headwaters

The Missouri River reservoir system is the largest in the United States with a storage capacity of 74 million acre feet and a surface area exceeding one million acres. The six dams built in Montana, Nebraska, North Dakota and South Dakota transformed one-third of the Missouri River ecosystem into lake environments.

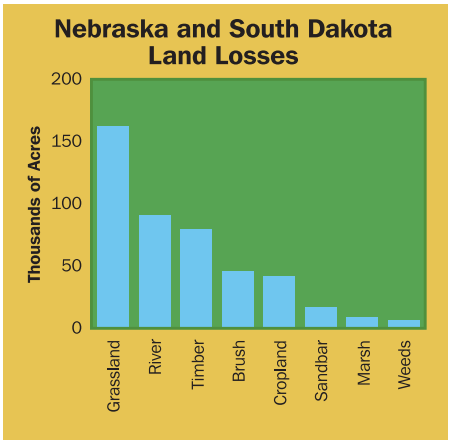
The original development plan called for a series of reservoirs to be built in order to lessen the effects of flooding in the lower basin and provide flows for navigation below Sioux City, Iowa. Upper basin benefits included irrigation and power generation. Though irrigation never developed as planned, economically important sport fisheries in the reservoirs and below the dams have developed.

Great quantities of sediment and organic materials flow into the reservoirs and are trapped behind the dams, reducing reservoir storage capacity and sediment transport below the dams. Dams block native fish migration to spawning grounds and modify the flow regime in the river system.

Deltas are formed at the reservoir headwaters from sediment mobilized in the inter-reservoir reaches and arriving from upstream tributaries. Deltas reduce reservoir storage and channel carrying capacity. Extensive wetlands have developed in the reservoir headwaters, providing excellent waterfowl and waterbird habitat and spawning areas for fishes.



Missouri River basin tribes lost 349,566 acres or 21% of the 1.6 million acres required for construction of the reservoirs.[33,47]



Almost 424,000 acres of river floodplain lands were inundated by the reservoirs in South Dakota and Nebraska. Over 75% of these lands consisted of grassland, timber, and aquatic riverine habitat.[44, 45, 48, 49]


Fort Randall Dam on Lake Francis Case

Delta formed at the headwaters of Lewis and Clark Lake on the border of Nebraska and South Dakota

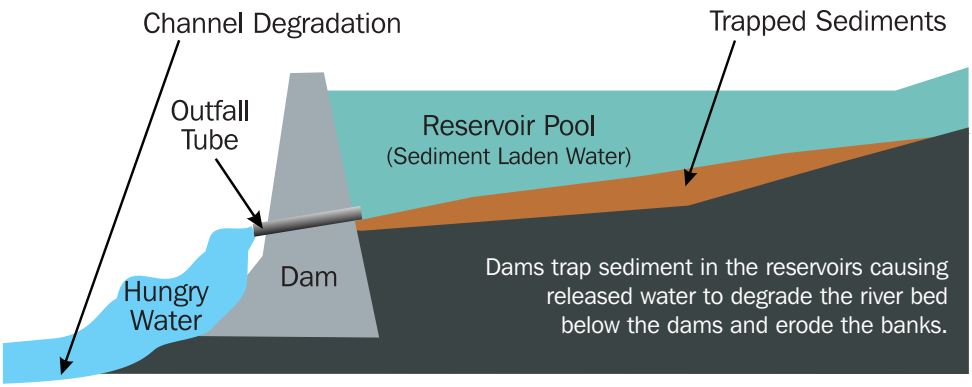
Inter-Reservoir Reaches

Inter-reservoir reaches run from directly below the dams to the headwaters of the next downstream reservoir. While these reaches maintain some of their pre-development channel morphology, they are affected by altered water temperatures, unnatural water level fluctuations, and changes in sediment and nutrient transport.

Sediment "hungry" water released from the reservoirs degrades or cuts the river bed below the dams lowering groundwater tables and dewatering side channels, sloughs, and backwaters connected to the channel. Deep reservoir releases lower water temperatures in reaches below the dams. Both of these factors interfere with native fish spawning and development.

Water levels in inter-reservoir reaches can fluctuate dramatically because of hydropower and flood control operations. Human encroachment in the floodplain of these reaches is creating a demand for additional flood control and bank stabilization.

Dams change the timing, magnitude, sediment load, and temperature of water coming down the Missouri River.



Water Flow Regime

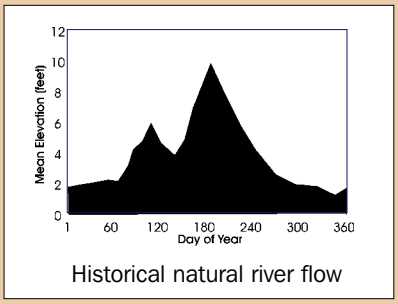
In the typical pre-development Missouri River flow regime, a flood pulse resulted from rain and melting snow runoff, first in March from the Great Plains and then during late June from the Rocky Mountains. Flows declined through the summer and fall reaching their low point in late December.[32]

Native fish and wildlife evolved with this historical flow regime and depend on it to meet their different seasonal habitat and reproductive needs.[3,42] Today a spring flood pulse is suppressed via reservoir storage, while dam releases provide higher river flows from July through November, eliminating summer/fall low-water flows.

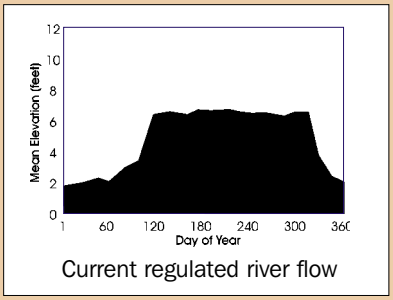
Seasonally inundated backwaters and wetlands historically provided food and habitat for native river fishes. The suppression of high spring flows has prevented recharging of these areas, reduced nutrient cycling and transport, and accessibility to floodplain and nursery habitats for fishes.

In relation to pre-development conditions, few high elevation sandbars form because of the suppression of high flows which are necessary to create them. Sandbars that do remain become covered with unwanted vegetation because the scouring flows needed to clear them are unavailable. Native fish spawning cues once triggered by increasing water temperatures coupled with rising river stages have been lost within many river reaches.

Flow Regime at Omaha, NE



Historical natural river flow



Current regulated river flow

Gavins Point dam serves as the main control point for water releases to the lower river.

Channelization

Historically, the "Big Muddy" changed course. The channel relocated over 2,000 feet or more a year in some places and deposited huge amounts of silt in other places. It is estimated that 11 billion cubic feet of sediment was carried past St. Charles, Missouri in 1879 – enough to cover a square mile of ground 200 feet deep.[9] Banks along the river would erode 200 to 300 feet during a single rise of the river.[9] It was the movement of this sediment that created braided channels in the meandering river, hampering navigation and the permanency of bottomland farms and river towns.

The Rivers and Harbors Acts of 1912, 1917, 1925, 1927, 1930, 1935, and 1945 each affirmed the desire of the floodplain occupants, the basin's elected officials, and the federal government to tame the river for navigation, development, and flood control.[9]

The Missouri River Bank Stabilization and Navigation Project created one stabilized channel from the numerous small channels. The plan entailed concentrating the water flow and shaping it in smooth easy bends so that the energy of the flowing water scoured out a deeper, more efficient, navigation channel.[9] Officially completed in 1981, 735 miles of the Missouri River from Sioux City, Iowa, to St. Louis, Missouri have been channelized or stabilized by the plan, allowing urban and agricultural development of the floodplain.[23]

Channelization Process at Indian Cave Bend, NE

1934

The wide natural river channel before channelization with sandbars, shallow water and riparian vegetation.

1935

Sediment collects behind wing dikes. The constricted river washes away sandbars and eliminates shallow water habitat.

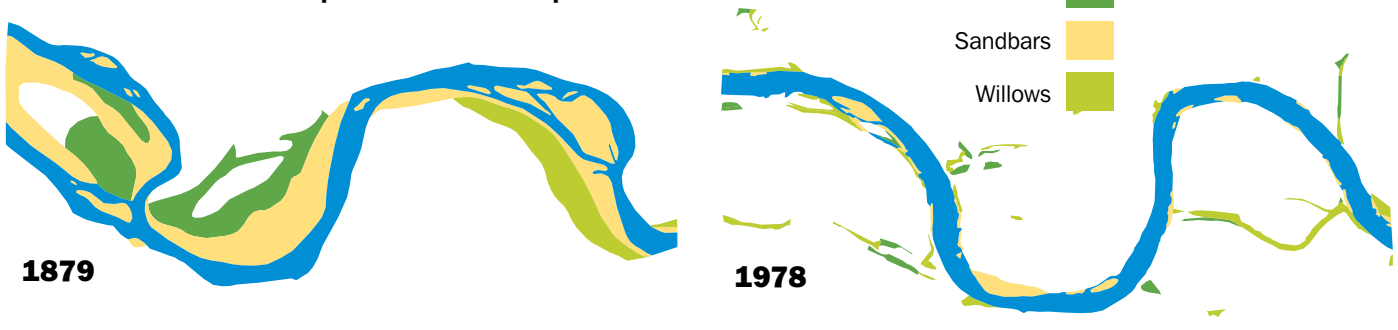
1946

Land accreted behind the wing dikes is colonized by forest communities.

1977

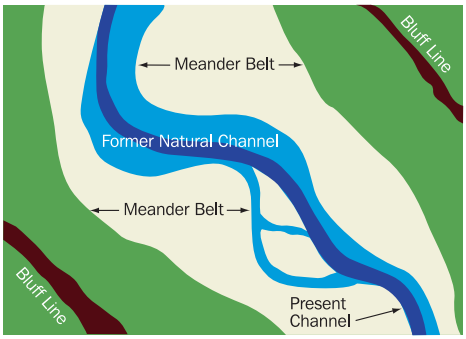
Forests are removed and accreted land is farmed.

More than half of the fish and wildlife habitat in the lower river meander belt has been lost due to channelization and resulting development of the floodplain.



Lower River Habitat Losses

From bluff to bluff, the river-floodplain below Sioux City, Iowa, covers 1.9 million acres. Historically, the river meandered across more than one-fourth of this floodplain acreage. This "meander belt" contained a variety of fish and wildlife habitats including wetlands, sandbars, wet prairies, and bottomland



forests. Seasonal floods provided the water needed to replenish shallow-water habitats used for fish and wildlife breeding and growth.

Channelization shortened the river 72 miles, resulting in a loss of 127 miles of river shoreline habitat. Aquatic habitat was lost as 168,000 acres of sediment accreted behind the wing dikes, forming new land. Nearly 354,000 acres of meander belt habitat were lost to urban and agricultural floodplain development. Levees, built to protect against flooding, allowed floodplain property investments. Levees isolated riverine off-channel habitats and wetlands from the river. [55]

The damage to fish and wildlife habitat was acknowledged in 1986 when the Corps was authorized to implement the Missouri River Fish and Wildlife Mitigation Project. The goal of the project is to acquire and restore 28,000 acres in Iowa, Kansas, Missouri, and Nebraska. This equals approximately five-percent of the habitat lost as a result of the Missouri River Bank Stabilization and Navigation Project.

Riverine Species at Risk

FISH

Pallid sturgeon
Scaphirhynchus albus
Lake sturgeon
Acipenser fulvescens
Flathead chub
Platygobio gracilis
Sturgeon chub
Macrhybopsis gelida
Sicklefin chub
Macrhybopsis meeki
Western silvery minnow
Hybognathus argyritis
Plains minnow
Hybognathus placitus
Blue sucker
Cycleptus elongatus
Burbot
Lota lota
Paddlefish
Polyodon spathula

BIRDS

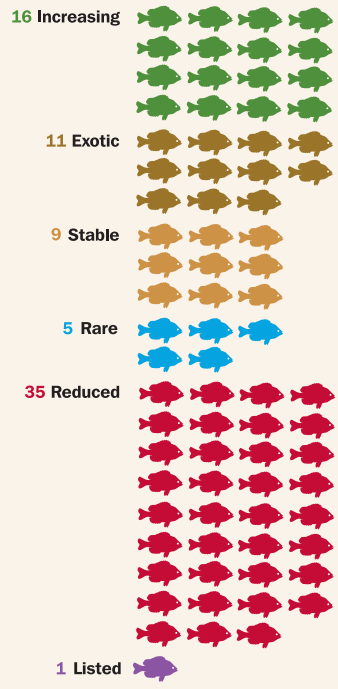
Interior Least Tern
Sterna antillarum athalassos
Piping Plover
Charadrius melodus
Bald Eagle
Haliaeetus leucocephalus

REPTILES

Eastern massasauga rattlesnake
Sistrurus catenatus catenatus

Status of 77 middle Missouri River fish species 1996

Historical data are often used to describe changes which have occurred in biological systems. Fish data collected over roughly 40 years were used to analyze trends in fish populations for the middle Missouri River.[20]



What went into creating the Program. Monitoring components, focused investigations, sampling strategies.

Missouri River Environmental Assessment Program

To develop the Missouri River Environmental Assessment Program (Program), the Missouri River Natural Resources Committee (MRNRC) initiated a cooperative Partnership with 79 scientists and river managers (complete list, page 31). From August, 1996, through June, 1997, these individuals worked more than 3,200 hours to develop a Program that will provide the understanding and information needed for the balanced management of the river.

Sixty-four issues dealing with the complex relationships between biota, habitat and river hydraulics and hydrology were used as the basis of the Program plan. To organize the planning process, these issues were assigned to either the aquatic, terrestrial, or water quality workgroups. Fourteen scopes of work were developed within these workgroups that serve as the foundation for the Program plan and cost estimates.

Scopes of Work

- defined an objective
- identified parameters to measure
- listed related issues
- identified methods to measure response variables
- defined the geographic scale of the monitoring effort
- identified when the monitoring should occur
- determined what the measurements say about operations
- defined a budget
- identified follow-up assignments

Goal

to provide the scientific basis for balanced management of the Missouri River's main stem and floodplain fish and wildlife resources while avoiding or minimizing conflicts with other river uses

Objectives

To understand and predict:

- species, community, habitat, and water quality response to different flow regimes (including intra-system regulation)
- biological response to structure addition, modification, or removal
- impact of physical changes due to aggradation (sedimentation) in reservoir upper reaches and degradation (incision) below the dams on biota and habitat

These program objectives will be met by developing and applying standardized system-wide testing methods in order to identify trends.

PARTNER AGENCIES

ASSOCIATIONS

Missouri River Natural Resources Committee
Missouri River Basin Association
Mni Sose Intertribal Water Rights Coalition
Mississippi Interstate Cooperative Resource Association

STATE

Iowa Department of Natural Resources
Kansas Department of Wildlife and Parks
Missouri Department of Conservation; Department of Natural Resources
Nebraska Game and Parks Commission; Department of Environmental Quality
Montana Department of Fish, Wildlife and Parks
North Dakota Department of Game and Fish; Department of Health
South Dakota Department of Game, Fish, & Parks;
Department of Environment & Natural Resources

FEDERAL

U.S. Army Corps of Engineers - Kansas City & Omaha Districts;
NW Division, Missouri River Region; Waterways Experiment Station
U.S. Bureau of Reclamation
U.S. Department of Agriculture - Natural Resources Conservation Service
U.S. Department of Energy - Argonne National Laboratory;
Western Area Power Administration
U.S. Environmental Protection Agency - Region 7 (Kansas City); Region 8 (Denver)
U.S. Fish and Wildlife Service - Region 3 (Minneapolis); Region 6 (Denver)
U.S. Geological Survey - Biological Resources Division; Water Resources Division

Program Plan

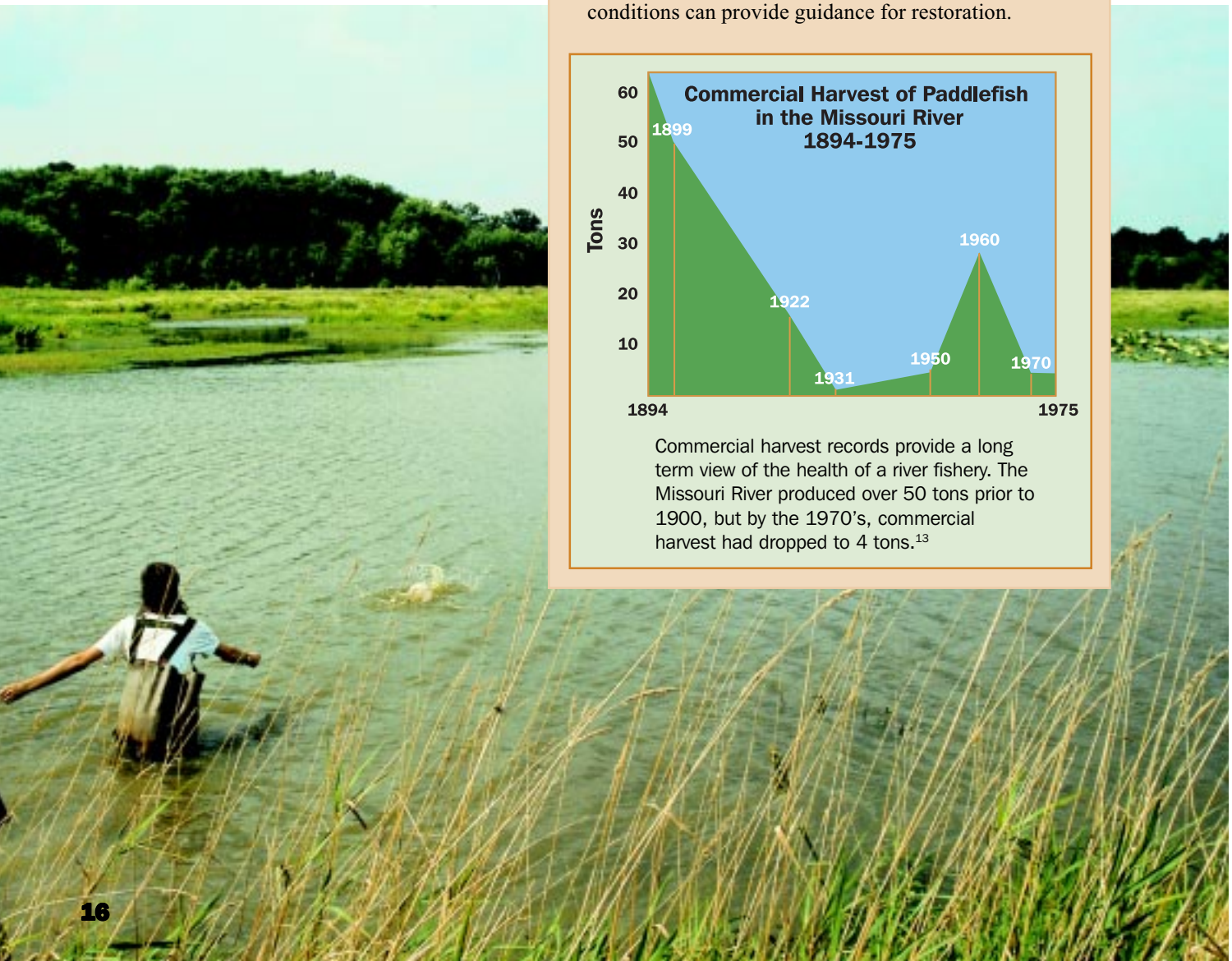
What is learned from long-term monitoring and focused investigations will be applied to habitat restoration and management activities by resource agencies and the Corps.

The Program proposes to both expand existing state and federal monitoring programs and initiate new monitoring efforts to assess the biological, physical, and chemical responses to changes in Missouri River system operation and maintenance (O&M). The Program will conduct:

Long-term monitoring - -
using consistent sampling methods to establish a system-wide database on Missouri River biota, habitat, and water quality, and define the baseline environmental condition of today's river which is lacking for much of the Missouri River[41]

Focused investigations - -
integrated with monitoring to predict cause-and-effect relationships between system O&M and the response of the biotic community

The Program will build upon existing data, studies, and sampling protocols. For example: Historical data will be used to establish how far today's Missouri River departs from natural patterns. Pre-development conditions can provide guidance for restoration.



Commercial harvest records provide a long term view of the health of a river fishery. The Missouri River produced over 50 tons prior to 1900, but by the 1970's, commercial harvest had dropped to 4 tons.[13]

Long-term Monitoring

To gain a system-wide scientific understanding of the Missouri River, an ongoing inventory of its biological, physical, and chemical conditions will be conducted by the Program.

These monitoring efforts will focus on three principal components of the Missouri River ecosystem: *fish and wildlife*, *habitat*, and *water quality*. These components will be monitored in the Missouri River, main stem reservoirs, selected tributaries, and in the main stem river's adjacent riparian corridor and floodplain from the Marias River confluence in Montana to the mouth at St. Louis, Missouri (see sampling map on page 24).

Inventories biological, physical, and chemical conditions to establish a system-wide understanding of the Missouri River

Identifies natural variation and trends within the system

Assesses changes resulting from periodic floods and droughts

MONITORING COMPONENTS

FISH & WILDLIFE

Fish: species composition, abundance, distribution, habitat use

Benthic invertebrates: species composition, abundance, distribution, habitat use

Birds: species composition, abundance, distribution and habitat use of shorebirds, herons, waterfowl, and eagles

Herpetofauna: species composition, abundance, distribution and habitat use of amphibians and reptiles

HABITAT

Aquatic: water depth, water velocity, substrate size and composition, quantity of large woody debris

Terrestrial: plant species composition of riparian and floodplain vegetation and wetlands; wetland surface area, volume, duration, and depth; number, area, and elevation of unvegetated sandbars; groundwater elevations; floodplain land cover; floodplain geomorphology and hydroperiod

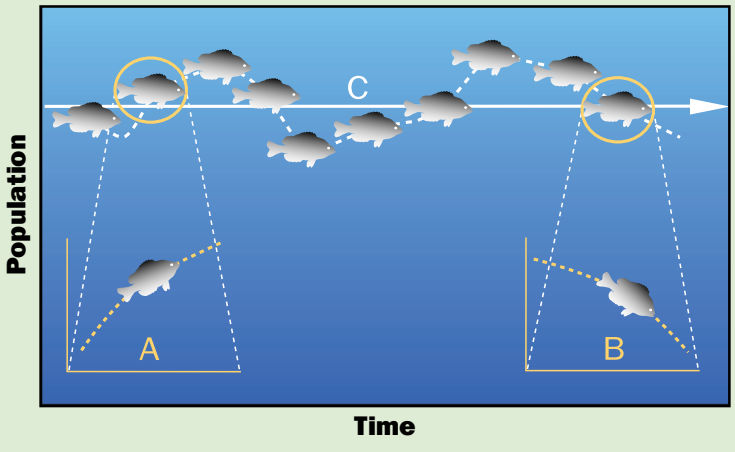
WATER QUALITY

River: dissolved oxygen, temperature, turbidity, and nutrients at stream gages and special study sites; survey of contaminants at NASQAN river stations; sample for contaminants and bioaccumulable hydrophobic organic compounds at special study sites if need indicated by previously collected survey data

Reservoir: dissolved oxygen, temperature, turbidity, and nutrients in water column throughout reservoir; sample for contaminants and bioaccumulable hydrophobic organic compounds at special study sites if need indicated by previously collected survey data

River Tributaries to Main Stem and Reservoirs: dissolved oxygen, temperature, turbidity, and nutrients at stream gages and special study sites; contaminant measurements if need indicated by previously collected data

Long Term Monitoring Identifies Variability



Data must be collected over a long period of time in order to characterize the inherent variability of populations. Without long term data, erroneous conclusions can be reached.

For example: if fish were sampled over the time period represented by A, the data would indicate an increasing population. If the sampling occurred for time period B, the data would suggest a decreasing population. When sampled over the long term, the data indicate the population is actually stable (C).

A healthy river ecosystem consists of a dynamic interaction between water, land, and biotic communities. Depending on river water levels, terrestrial and aquatic habitats shift back and forth.[3] To understand fish and wildlife habitat needs, the interaction between the river and its floodplain must be understood.

Piping Plover

The variety of Missouri River habitats are defined in large part by the water and how it flows.

Main channel	Middle portion of riverine habitat defined by highest current.
Side channel	Area of moving water which is physically separated from main channel by island or sand.
Back water	Area of minimal velocity where smaller particles settle.
Littoral	Shallow, oxygenated shoreline zone of active biological and physical activity.
Profundal	Permanently flooded deepwater reservoir environment.
Tailwater	Area immediately below dam with high influence of O&M.
Reservoir headwater	Shallow, upper portion of reservoir subject to changes in depth and current velocity.
Sand island	Sand deposit which extends above level of water; possibly vegetated.
Floodplain wetland	Wetland area not immediately adjacent to littoral area.

HABITAT

How Missouri River fish and wildlife relate to the habitat in which they live and reproduce is a crucial component of understanding the effects of river system management on the health of their populations. River and floodplain habitats important to fish and wildlife will be monitored to:

- detect year-to-year changes in habitat quantity and quality
- determine how habitat quantity, quality, and availability varies with changes in river flows, degree of structural modification, and climatic events
- link habitat quantity and quality to fish and wildlife use and productivity

Aquatic

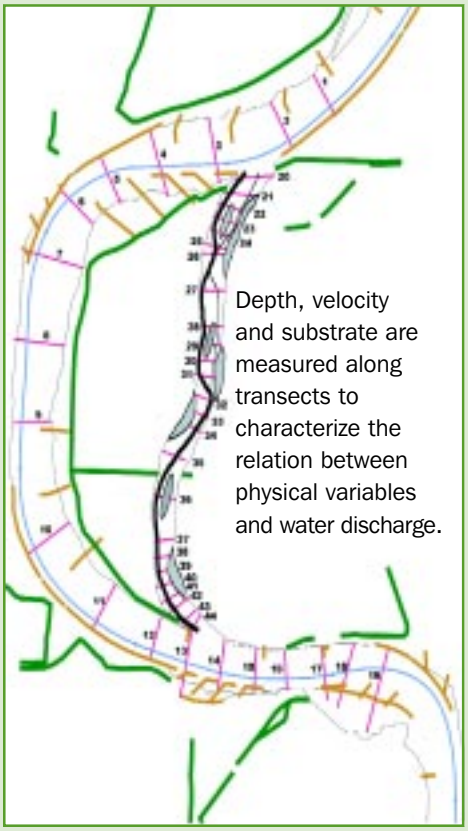
Aquatic habitat variables to be routinely measured in various river and reservoir habitats include water depth, water velocity, substrate size and composition, and quantity of large woody debris.

Terrestrial

Terrestrial habitat variables that will be measured are surface area, depth, volume, duration, elevation, and frequency of floodplain wetlands; the areal extent and vegetative composition of riparian forests; and the number, area, elevation, and vegetative composition of river and reservoir delta sandbars.

Floodplain land cover, including wetlands, floodplain forest, cropland, oxbow and scour lakes, and other cover types will be measured once every 10 years.

Interior Least Terns



Depth, velocity and substrate are measured along transects to characterize the relation between physical variables and water discharge.

Missouri River fish and wildlife habitats are created and maintained by the interaction of water and the floodplain. Recent technological advances make it possible to record water depth and velocity, substrate morphology and floodplain elevation providing a "3-D" view of the river and its floodplain.

Using these measurements in a hydraulic habitat model allows managers to link habitat availability directly to river flows, reservoir releases, and structural changes to the channel or floodplain.

For example, knowing the availability of unvegetated sandbars for nesting interior least terns and piping plovers at certain flows would assist in optimizing reservoir releases for both the birds and other river purposes, such as water supply and navigation.

Accurate and detailed habitat measurements are also needed for management of existing fish and wildlife habitat areas on the river, reservoir releases, design and repair of channel maintenance structures, and design and evaluation of future habitat restoration efforts.

The species chosen to be monitored represent those in decline or species that are most sensitive to changes in water flow.

FISH & WILDLIFE

All fish and wildlife will be monitored for species composition, abundance, distribution, and habitat use.

Fish will be monitored because they are sensitive to changes in flow regime, water levels in reservoirs and off-channel habitats, water temperatures, turbidity, food resources, and substrate composition. Furthermore, benthic fish, which comprise most of the declining species in the system, are entirely dependent on riverine habitats. Data gathered will allow greater understanding of how reservoir levels and releases, water temperatures, channel structures (revetments and wing dikes), habitat restoration projects, and tributaries affect fish habitat and fish productivity, especially for the at-risk benthic species and economically-important reservoir and tailwater sport fisheries.

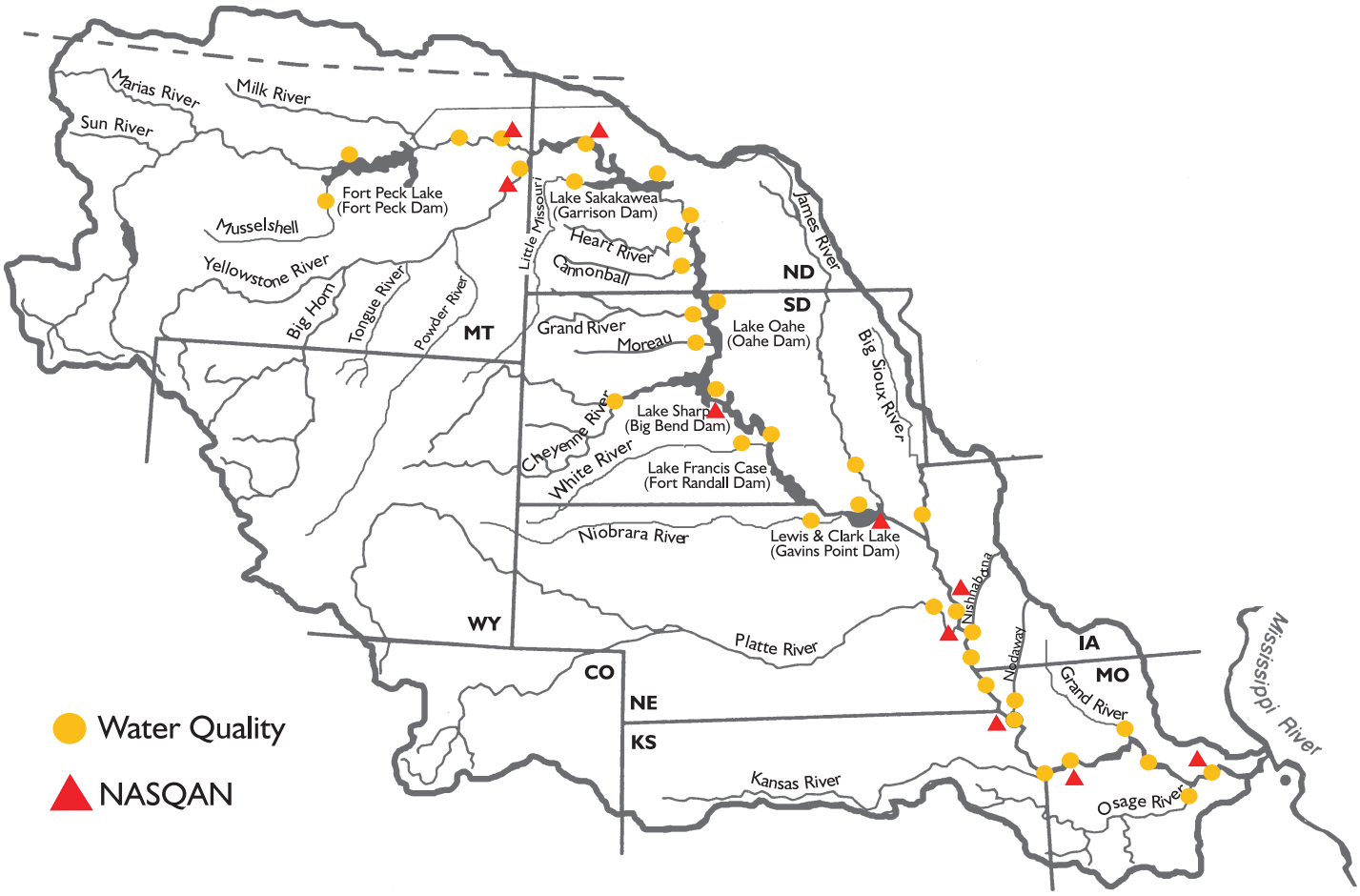
Herpetofauna (amphibians and reptiles) will be monitored because these organisms inhabit both the river and its floodplain, are sensitive to change, and do not require elaborate or expensive monitoring equipment and methods.

Benthic Invertebrates are critical components of the food web, providing food resources for fish, waterfowl, and shorebirds. Benthic invertebrates will be monitored because they are sensitive to nutrient enrichment, substrate composition, and water temperatures and velocity. They use both artificial (rock revetments and wing dikes) and natural (silt, woody debris, gravel, plants) substrates of the river and reservoirs.

Birds. Interior least terns, piping plovers, other shorebirds, waterfowl, wading birds, and bald eagles will be monitored annually.

Monitoring reproductive success and habitat use of the federally listed interior least tern and piping plover will be a major focus. These birds depend on unvegetated sandbars to nest, and shallow waters to forage for fish (least terns) and invertebrates (plovers). Nesting habitat availability and reproductive success is dependent on effective management of river flows during the nesting period. Knowing the year-to-year status of nesting birds and sandbar habitat is a critical need for wildlife managers to make informed recommendations on reservoir releases.

Waterfowl, shorebirds, wading birds, and eagles will be censused using aerial surveys. Census data will be integrated with habitat monitoring to determine optimum seasonal river and reservoir levels for maintenance of wetland and aquatic habitats for these species.



WATER QUALITY

Monitoring the chemical composition of the water in the Missouri River will provide the information needed to determine if or when water quality is a limiting factor to the recovery of fish and wildlife populations, and how water quality varies with Missouri River flows, reservoir volume and elevation, and tributary inflows.

Twenty-five standard water quality parameters, including dissolved oxygen, temperature, and turbidity, will be measured to assess the suitability and trophic state (degree of nutrient enrichment) of various river reaches, and reservoir and wetland habitats. Contaminants will be monitored to assess the transport and fate of potential toxins in aquatic and terrestrial habitats, and how these processes are affected by river flows and reservoir fluctuations.

Water quality monitoring will build upon an existing USGS stream gaging and water quality network on the Missouri River main stem by increasing the number of parameters measured and adding sites on tributaries and reservoirs. Building on existing data collection networks allows the Program to expand upon 30 years of existing data, reduce redundancy, and more efficiently use resources.

For the contaminants component, the existing USGS National Stream Quality Accounting Network (NASQAN) will be augmented by upgrading the station at St. Joseph, MO, and adding stations at Yankton, SD, and Waverly, MO. In addition to main stem river, reservoir, and tributary contaminants monitoring, site-specific aquatic and terrestrial habitats will be monitored for contaminants once every five years.

Focused Investigations

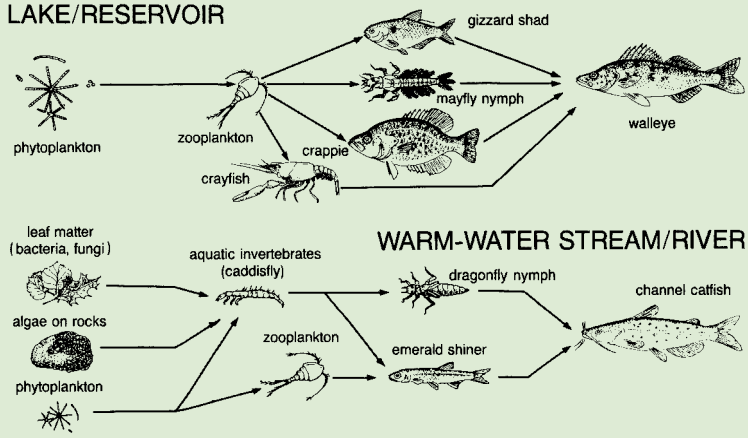
Build upon the monitoring effort

Identify the complex linkages between O&M, physical variables, habitat, and biota

Identify cause and effect relationships and develop a predictive capability

Evaluate restoration methods for fish and wildlife conservation and management

Focused investigations will build on the monitoring effort and are intensive, usually short term, site-specific studies. The measurements taken as part of a focused investigation will usually be at a higher level of resolution (in both space and time) than those associated with monitoring.



Food webs illustrate the complex biotic relationships operating in reservoir and river aquatic communities. Focused investigations will assist in explaining how O&M affects these relationships which in turn affect the status and health of aquatic communities.

Observing the movements of endangered species such as the pallid sturgeon will help scientists understand the effects of Missouri River O&M on fish and wildlife habitat.

Examples of Focused Investigations

Adaptive management experiments such as special reservoir releases or structural modifications to habitat areas.

Hydraulic model development, testing, and application to link system O&M to habitat availability and biotic response.

Original experiments at special study sites to answer specific questions regarding biological, physical, and chemical processes.

Special surveys of non-monitored fish and wildlife where little information exists, such as basic surveys to determine Missouri River mussel community composition and distribution.

Life history of native river cyprinids and sturgeons.

Relating O&M to Biotic Response

O&M modifies the PHYSICAL FACTORS –

the PHYSICAL FACTORS influence the development and modification of HABITAT –

the amount and quality of HABITAT affects the BIOTIC community –

PHYSICAL FACTORS

- Water velocity
- Discharge volume
- Water temperature[18]
- Turbidity[18,19]
- Sediment transport[40]
- Channel form[10,16]
- Bed mobility[31]
- Pollution[11]
- Organic matter[5,17,18]
- Reservoir elevation & vegetation
- Fragmentation of habitats[50]
- Tributary access[31]
- Riparian flooding[26,27,50,54]

HABITAT

- Islands
- Chutes
- Side channels
- Sandbars
- Sand island shoals
- Slack water refugia
- Woody debris & snags[5,11,18]
- Substrate
- Turbidity (as cover)[14,51]
- Hydraulic habitat[15,29,34,39]
- Temporary wetlands, oxbows, etc.

BIOTA

- *Vegetation succession:* bottom-land forests, wet prairies, etc.
- *Community structure:* diversity and abundance of fish, benthic invertebrates, birds, and herpetofauna
- Reproduction
- Growth rates[4]
- Migration routes
- Exotic species[4]

SYSTEM OPERATION (O&M)

- Timing, magnitude, & duration of reservoir releases[11,43]
- Reservoir elevations
- River structure construction & maintenance (wing dikes, revetments, levees)
- Habitat restoration projects

Focused investigations will provide system managers the detailed information needed to understand the complex connections between O&M and biological, physical, and chemical processes throughout the Missouri River system.

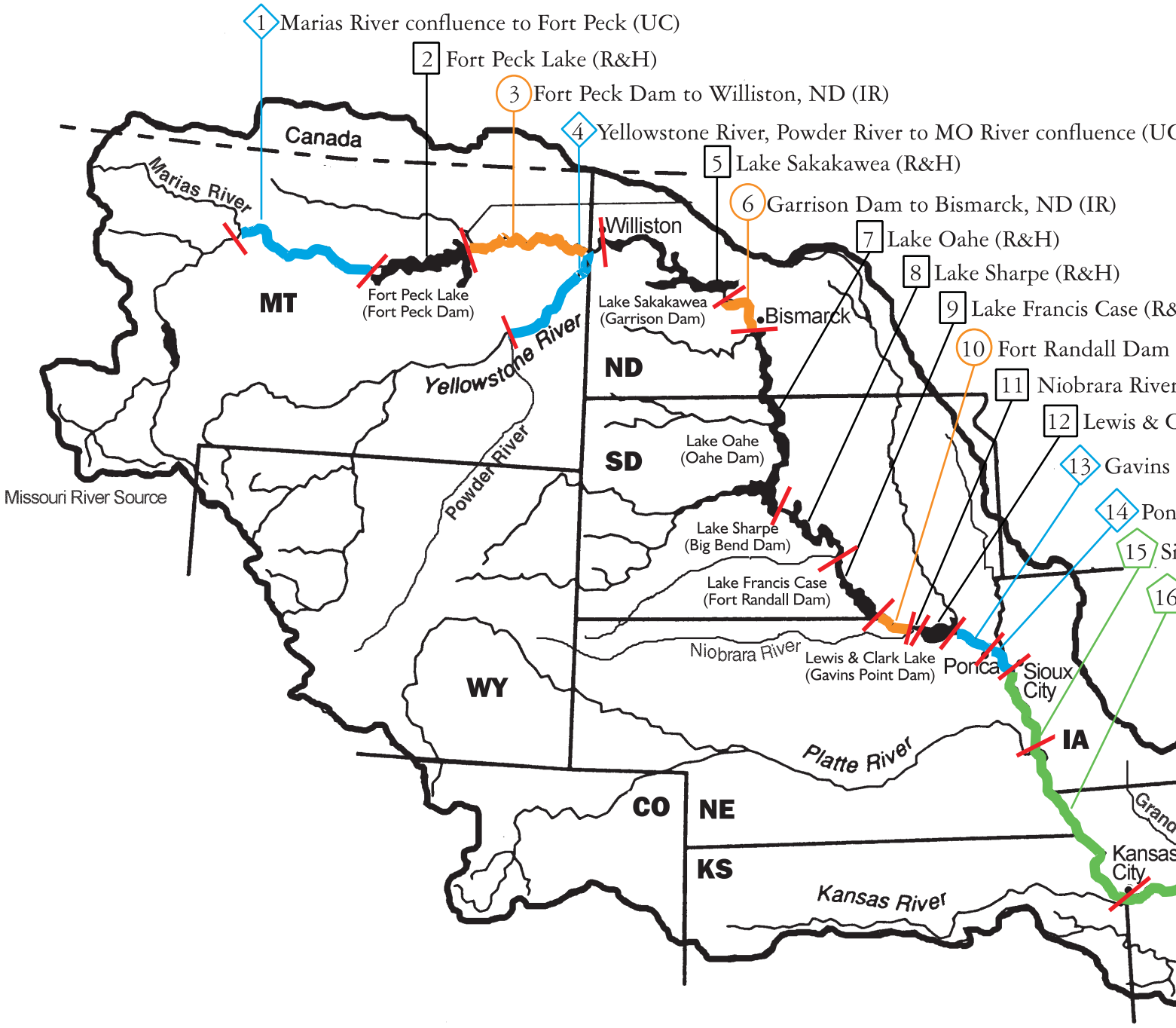
Sampling strategy

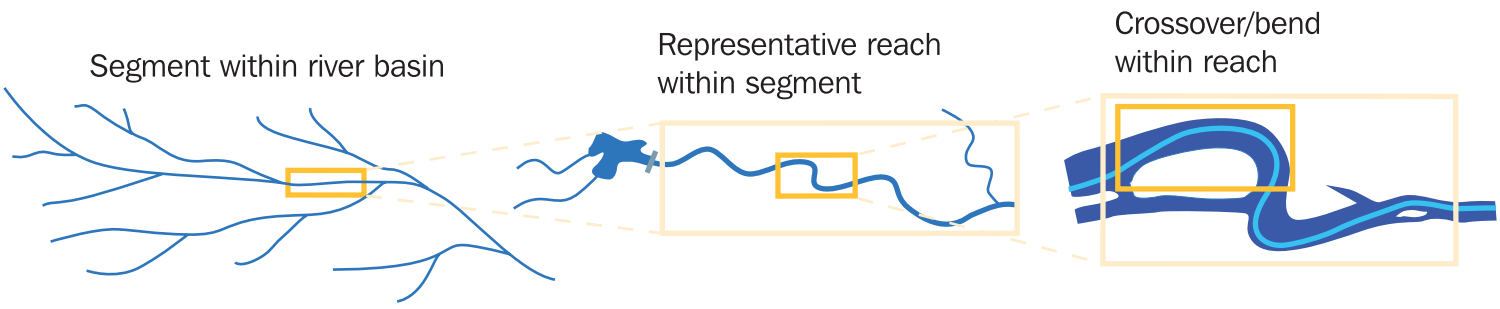
The river has been divided into four distinct ***sections*** based on modern river conditions: unchannelized, reservoir and headwaters, inter-reservoir, and channelized. It has then been further divided into nineteen segments based on unique morphological characteristics.

Sections

- Unchannelized (UC)
- Reservoirs & Headwaters (R&H)
- Inter-reservoir (IR)
- Channelized (C)

Segments





To conduct comparative sampling, ***segments*** have been delineated within each section type.

Within a segment, a 4-6 mile ***representative reach*** will be used for focused investigations that link O&M to biotic response.

Crossover/bends and ***macrohabitats*** represent repeatable features throughout the riverine portion of the system.

This sampling strategy allows data collected at the macrohabitat, crossover/bend, and representative reach scales to be aggregated or summarized at the segment and section levels.

C)

&H)

to Niobrara River (IR)

to Lewis & Clark Lake (R&H)

Clark Lake (R&H)

Point Dam to Ponca, NE (UC)

ca, NE to Sioux City, IA (UC&C)

oux City, IA to Platte River (C)

Platte River to Kansas City, MO (C)

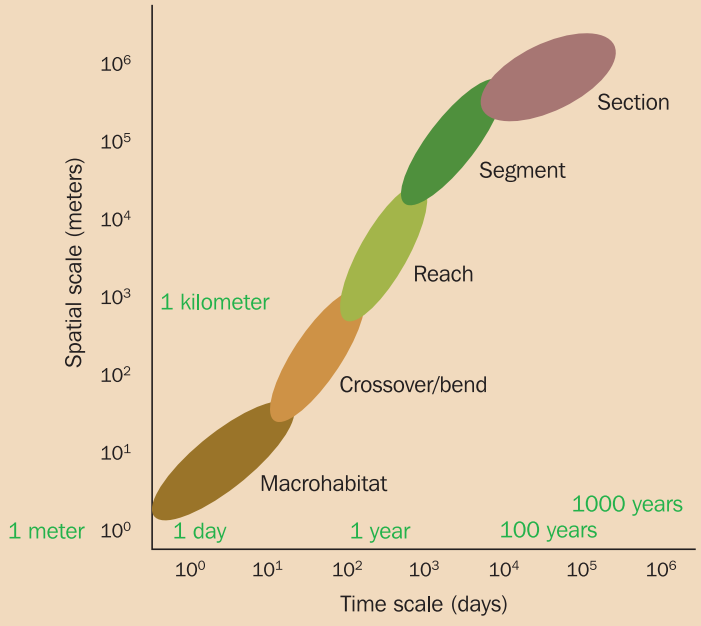
17 Kansas City to Grand River (C)

18 Grand River to Osage River (C)

19 Osage River to the mouth (C)

Scale

Processes which define the structure and function of riverine ecosystems operate at different scales in space and time.[1] Generally speaking, the smaller the area, the more dynamic it is (greater variability) and the quicker it changes over time. Therefore, the intensity of sampling effort must increase from the segment to the macrohabitat. For example, the segment is the appropriate scale to investigate the effect of reservoir operations over decades. The crossover/bend is appropriate for investigating the seasonal flood pulse, and the macrohabitat for tracking daily fish movement.



Administration and Central Support

It is recommended that the U.S. Geological Survey, Biological Resources Division (USGS-BRD) in Columbia, MO serve as the Program administrator, receiving Congressional authorization and appropriations for the Program. The USGS-BRD will develop an interagency cooperative agreement with the Missouri River Natural Resources Committee (MRNRC) state member agencies. The MRNRC will be responsible for developing Program policy.

This USGS-BRD Columbia facility is qualified to provide Program coordination and central support. It has developed a working relationship with the state and federal partners within the Missouri River basin and this activity is supported at the highest levels within the USGS-BRD. Through the USGS-BRD sponsored Missouri River Ecosystem Initiative, the facility has developed an information transfer capability. Currently, the facility is establishing the River Studies Center, a multi-disciplinary group dedicated to providing unbiased scientific information on the impacts of habitat alteration on aquatic ecosystems. For the Program, the USGS-BRD will coordinate monitoring efforts, compile existing data, conduct statistical analyses, serve as the database manager, develop hydraulic models, facilitate the mapping of river depth, velocity and substrate, and assist in the development of sampling protocols.

Coordination & Outreach

Annual coordination meetings will be held between MRNRC and the Missouri River Basin Association to review annual progress, discuss the work plan for the upcoming year, and continuously refine the Program**.** At five-year intervals, Program progress to-date will be evaluated and the direction for the next five years determined, including the reprogramming of funds.

An independent scientific review committee will be established to provide Program guidance. All data and reports generated by the Program will be available to the public in both hard copy and electronic format. The public will be encouraged to participate in the Program through public meetings, workshops, and an internet home page.

Program Duration

The Program is proposed for fifteen years with the option to extend it if needed. At least fifteen years are needed to establish baseline data, develop a predictive capability, and identify statistically reliable trends, linkages between O&M and biotic response, and successful rehabilitation strategies.

Field Stations

The Program proposes to establish five Missouri River field stations to conduct long term monitoring. Field stations will be located in Montana, North Dakota and South Dakota with shared facilities in Missouri-Kansas and Nebraska-Iowa. The field stations will be financed by the USGS-BRD and operated by the states.

Focused Investigations

Focused investigations will be funded using a competitive process. Each year, the MRNRC will prioritize information needs and issue a request for proposals to state, federal, for-profit, and not-for-profit organizations with Missouri River interest and expertise. The MRNRC will review proposals and select those which best address Program needs.

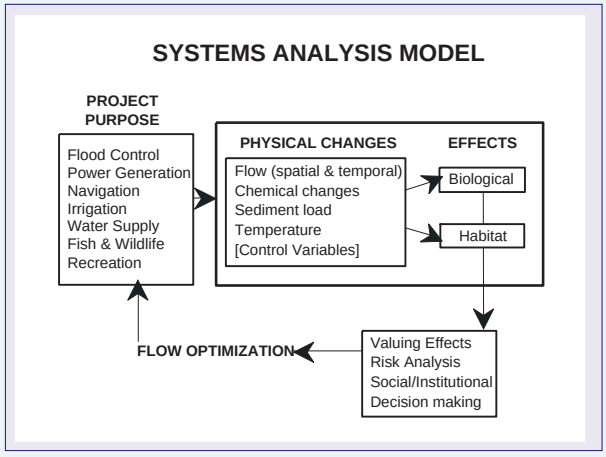
Budget
(in millions $)

5 Field stations[1]	5.2
Central support	1.4
Contracts[2]	2.5
Overhead[3]	.9
Focused investigations	2.5
Total annual Program cost	12.5
Total annual Federal contribution	10.7
Total annual contribution by states	1.8
One-time start-up costs[4]	3.3

1 - Includes $1.8 million in-kind contribution by the states
2 - to build upon and expand existing monitoring networks
3 - estimated at 12%
4 - includes equipment, vehicles, computers

Detailed cost estimates are available upon request.

Total annual costs of this Program represent less than 1 percent of the annual benefits of the Missouri River reservoir system as estimated by the Corps in the *Master Manual Draft Environmental Impact Statement.*



The *Program* will provide detailed biota and habitat inputs needed for basin system analysis models which can be used to predict the consequences of management decisions on all project purposes.

The Missouri River Environmental Assessment Program will provide an unbiased, scientific foundation for future Missouri River management decisions. The public and agencies with natural resource and human health responsibilities will have equal access to a common database describing the biological, physical, and chemical conditions of the Missouri River system. The data can be used in models that predict the impact of management decisions on all river project purposes–flood control, navigation, irrigation, hydroelectric power generation, water supply and quality, recreation, and fish and wildlife.

Accurate and timely data on resource and habitat conditions and trends, combined with focused investigations which link O&M to biotic response over time, will provide the tools to test adaptive management strategies geared toward habitat restoration.

The Missouri River has been highly modified over the past 60 years in order to meet the needs of the basin's population and economy. The river will continue to serve those needs. The task before us is to integrate habitat restoration and conservation efforts with all of the beneficial uses currently provided by the river and to do it in a way that minimizes conflict. A proactive restoration effort, with built in checks and balances, will move us toward a Missouri River capable of sustaining and enhancing fish and wildlife populations. Future generations will enjoy a healthier ecosystem and enhanced recreation throughout the entire river system.

GLOSSARY

Adaptive management strategy An experimental approach to management that changes based on feedback (learning) during the experiment.

Aggradation To add to or raise, as the bed of a river by the deposition of silt.

Aquatic Living or growing in or near water: *aquatic* plants or birds.

Backwaters Off-channel areas characterized by low water velocities and shallow depths.

Bathymetry Mapping the bed of a water body.

Benthic Pertaining to the river bottom or bed.

Benthos The organisms living at the bottom of a water body.

Biological Of or pertaining to the science of life.

Biota Fish, wildlife, and plants

Channelization: The act of straightening and/or constricting a river or stream to speed the movement of water.

Chute A narrow river channel often associated with a convex river bend.

Contaminants Chemical pollutants

Dam A barrier to obstruct or control the flow of water.

Degradation Lowering of a river bed or landform, erosion.

Delta A river-deposited land form, composed of silt, found in reservoir headwaters and at the mouths of rivers where they enter reservoirs.

Deposition The act of depositing; also, that which is deposited.

Detritus Any mass of disintegrated material; debris.

Digital Elevation Model (DEM) A computer generated representation of the earth's surface.

Ecosystem The basic unit in ecology, including both organisms and the nonliving environment.

Erosion The wearing away of the earth's surface by the action of wind, water, glaciers, etc.

Flood pulse Inundation of the floodplain or portion thereof associated with rising river levels in the spring.

Floodplain A plain adjacent to a river, subject to flooding by the river and often originally formed by waterborne deposits.

Focused investigations Investigations that are narrow in scope and the results of which can be replicated.

Geomorphology The study of the development, configuration and distribution of the surface features of the earth.

Habitat The home or dwelling place of an organism.

Headwaters The tributaries or other waters that form the source of a river.

Herpetofauna Amphibians and reptiles.

Hydroclimatic The water component of climate which is characteristic of a region.

Hydrograph Water discharge or elevation plotted against time.

Hydraulic modeling The mathematical representation of water movement over, across or through a surface.

Invertebrates Animals lacking a backbone or spinal column (insects, worms, clams, etc.).

Intra-system Within the (reservoir) system.

Island A tract of land entirely surrounded by water.

Levee An embankment along the shore of a river, built for protection against floods.

Limnetic Pertaining to organisms inhabiting inland waters.

Limnology The scientific study of fresh water with reference to their physical, biological, and other features.

Littoral Pertaining to the region between the shoreline and the outer limit of rooted plants.

Main stem The Missouri River proper, excluding tributaries.

Master Manual The rules governing the operation of Missouri River dams used by the Corps of Engineers.

Meander belt The zone created by the lateral movement of a river as it interacts (erosion, deposition) with its floodplain.

Mitigation Offsetting over-exploitation of a habitat by restoring or preserving a subset of that habitat.

Morphological Structure and form.

Nutrient cycling The movement of any substance which promotes growth or provides energy for physiological processes from one state (inorganic, organic) to another.

Off-channel Landward of the river bank.

Operation and maintenance The manipulation of dam releases to affect river flows and the maintenance of the river's course through the placement of rock structures.

Organic material Any material containing carbon. Breakdown products of living organisms.

Oxbow An off-channel water body created by the migration of a channel across meander loop.

Physical The structure, properties, and energy relations of matter apart from the phenomena of life.

Physiographic Dealing with the natural features of the earth.

Productivity The manufacture of organic compounds from simple inorganic substances.

Representative reach A 4-6 mile section of the river which is characteristic of a segment.

Reservoir A basin, either natural or artificial, for collecting and containing a supply of water.

Riparian Pertaining to the habitat directly adjacent to a river, lake, or stream.

Riverine Pertaining to or like a river.

River flows The volume of water moving through a river system or river reach.

River reach A generic term for a section of river, regardless of scale.

River stage Water elevation above a fixed reference.

Sandbars A ridge of silt or sand in rivers formed by the action of currents.

Scouring The removal of river bed material by high velocity currents.

Sediment Sand, silt, or clay carried or deposited by the river.

Segments River sections (19) delineated by major tributary inflows and/or by unique geomorphological characteristics.

Slough An off-channel backwater characterized by low water velocities.

Spatial Pertaining to or involving the location and/or geometry of an object.

Spawning To produce and deposit eggs, with reference to aquatic animals.

Stabilization To keep from changing or fluctuating.

Substrate Referring to the composition of a river bed: boulder, cobble, pebble, sand, silt, clay, etc.

Tailwater The area immediately below a dam.

Temporal Having to do with time.

Terrestrial Pertaining to land as distinct from water.

Turbidity Sediment suspended in water.

VLPOM Very large particulate organic matter.

Wildlife Any animals other than fish.

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